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*The Connecticut Agricultural Experiment Station, New Haven*

# Winter Squash Trials 1997-1998

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## SUMMARY

In 1997 and 1998, six cultivars of butternut, five cultivars of buttercup, and eight cultivars of acorn winter squash were tested for yield and plant characteristics. The cultivars selected were mostly short-vined and bush types, but long-vined cultivars were also grown for comparison. The tests were conducted at the Valley Laboratory in Windsor on a well drained sandy terrace soil (Merrimac sandy loam) and at Lockwood Farm in Mt. Carmel (Hamden) on a moderately well drained loamy upland soil (Watchaug loam).

In 1997, average yield of six cultivars of butternut squash was 12.5 tons per acre (T/A) at Windsor compared to 14.4 T/A at Mt. Carmel. Yield of long-vined Nicklow's Delight exceeded 21 T/A at both sites. At Windsor, yield of Harris Butternut exceeded 15 T/A as did Butter Boy and Waltham at Mt. Carmel.

Average yield of five cultivars of buttercup squash at Windsor was 23.1 T/A compared to 8.3 T/A at Mt. Carmel. Lower average yield at Mt. Carmel was due to poorer germination during early drought and excessive soil wetness in August with occasional ponding. The butternut cultivars were less affected by these stressful conditions. Yield of long-vined Burgess Buttercup had the greatest yield at both sites, but the yield at Windsor (30.6 T/A) was more than double the yield at Mt. Carmel (14.4 T/A). At Windsor, yield of short-vined Autumn Cup and long-vined Sweet Mama exceeded 22.0 T/A.

In 1998, average yield of five cultivars of butternut squash at Windsor was 16.3 T/A compared to 9.8 T/A at Mt. Carmel. Lower average yield at Mt. Carmel was due to stunting of vine growth and poor fruit set during heavy rains in June. At Windsor, yield of long-vined Nicklow's Delight and Waltham exceeded 18.0 T/A. At Mt. Carmel, yield of Nicklow's Delight, Harris Butternut, and Butter Boy exceeded 10.0 T/A.

Average yield of eight cultivars of acorn squash was 13.2 T/A at Windsor, compared to 7.4 T/A at Mt. Carmel. Low average yield at Mt. Carmel again was due to stunted plants and poor fruit set. At Windsor, short-vined Tay-Belle and Mesa Queen had yields exceeding 17.0 T/A. Tay-Belle had the heaviest fruit (2.1 lb) among all acorn cultivars. Table King, a bush cultivar, had the greatest number of fruit/A (21,490), but their fruit averaged only 1.4 lb. At Mt. Carmel, short-vined Table Ace and Tay-Belle had greatest yields (10.0 T/A) among all acorn cultivars.

In the well drained soil at Windsor, average vine length of long-vined cultivars of butternut squash was 10-12 feet, short vined 6-8 feet, and bush 3-4 feet. The width of the fruiting zone (area containing 90% of fruit) was 15 feet for long-vined cultivars, 5-8 feet for short-vined cultivars, and 3 feet for bush cultivars.

Average length of long-vined cultivars of buttercup squash was 21-38 feet and 15-17 feet for short-vined cultivars. The width of the fruiting zone for long-vined cultivars of buttercup squash was 11-24 feet and 10-12 feet for short-vined cultivars.

Average length of long-vined acorn squash cultivars was 10 feet, 5-7 feet for short-vined cultivars, and 2-3 feet for bush cultivars. Average width of the fruiting zone was 9 feet for long-vined cultivars, 4-7 feet for short-vined cultivars, and 2-3 feet for bush cultivars.

In the moderately well drained soil at Mt. Carmel, the average vine length and average width of the fruiting zone of buttercup squash were 33% and 40% less, respectively, compared to Windsor; for acorn squash 14% and 11% less, respectively. Butternut squash was not adversely affected by wetness at Mt. Carmel.

Based on observations of plant habit, the estimated spacing between rows for butternut and acorn squash is 6 feet for long-vined cultivars, 5 feet for short-vined cultivars, and 3 feet for bush cultivars. The estimated spacing between rows of buttercup squash is 8 feet for long-vined cultivars, and 6 feet for short-vined cultivars. A plant spacing of 1 foot within rows for all squash types will maximize yield.

# Winter Squash Trials 1997-1998

**By David E. Hill**

Winter squash are members of the genus *Cucurbita* whose fruits, domesticated from wild strains, develop hard rinds that allow prolonged storage during winter months. In this study, cultivars of three species *C. pepo* (acorn), *C. moschata* (butternut), and *C. maxima* (buttercup) were tested.

Archeological evidence places wild strains of *C. pepo* in central Mexico and the eastern United States 10,000 and 30,000 years ago, respectively (Robinson and Decker-Walters 1997). *C. moschata* was cultivated by pre-Columbian Indians in Mexico and northern South America. The origin of *C. maxima* was in Argentina and Uruguay. Subsequently, they were imported into the northeastern United States from South America in Eighteenth Century trading ships. Because this species was more cold tolerant than *C. pepo*, it became very popular in New England.

Wild strains of winter squash were first gathered for their edible seeds and their dried rinds served as durable containers. Ultimately they were domesticated by Mayan, Aztec, and Incan civilizations and their flesh became a significant food staple. Nutritionally, winter squash are important sources of vitamin A, B2, and fiber, but low in fat (Anon. 1971).

### *Current outlook*

Today, winter squash are becoming increasingly popular for fall sales at roadside stands and sales rooms. Virtually all direct marketers of fruit and vegetables feature a variety of winter squash types whose versatility in preparation of vegetable dishes and desert treats and their excellent storability enhance their value.

Most squash for direct sales are grown in small patches on the farm, but large acreages for wholesale distribution are not uncommon. Home growers, in the past, usually shunned winter squash because of their great demand for garden space. New short-vined and bush types, developed in the last 20 years to alleviate space constraints, have increased home gardener interest.

Although the current acreage devoted to winter squash is unknown, the 1992 Census of Agriculture enumerated 288 Connecticut farmers growing squash (winter and summer) on 934 acres compared to 1987 when 142 farmers grew squash on 376 acres (Anon. 1992). The increase of 145 farmers on 558 more acres in that 5-year period is testimony to the increasing popularity of squash.

In this Bulletin, I report on yield and plant characteristics of 20 cultivars of winter squash (butternut, buttercup, and acorn) grown at Windsor and Mt. Carmel in 1997 and 1998. I also discuss strategies to maximize yield and profit through cultivar selection and minimum spacing requirements for long-vined, short-vined, and bush cultivars.

## METHODS AND MATERIALS

*Soils.* Winter squash trials were conducted at the Valley Laboratory, Windsor on Merrimac sandy loam, a sandy terrace soil with somewhat limited moisture holding capacity, and at Lockwood Farm, Mt. Carmel on Watchaug loam, a moderately well drained loamy upland soil with moderate moisture holding capacity.

*Cultivars.* The trials were centered on cultivars that are described in seed catalogues as being compact or semi-bush, or short-vined or bush. These cultivars are popular with home gardeners whose space limitations preclude growing long-vined cultivars. The "space savers" chosen for the trials were compared to standard long-vined cultivars. The cultivars used in the trials are listed in Table 1.

The categories in which the cultivars were placed are based on vining habit described in seed catalogues. In the absence of a catalogue description, I have taken the liberty to categorize them based on their habits observed in the trials. Plant habits of individual cultivars will be discussed later.

*Culture.* Between June 10-20 in both years, seeds of each cultivar were sown 6 inches apart in 50-foot rows set 6 feet apart. In 1997, the rows alternated between butternut and buttercup cultivars and in 1998 between butternut and acorn cultivars.

*Fertilization.* Prior to direct seeding in the field, the soils at both sites were fertilized with 10-10-10 at a rate of 1000 lb/A (100 lb/A N). After 4 weeks, as the vines began to run,

Table 1. Cultivars of winter squash used in 1996-1997 trials.

| | Long-vined or Full-vined | Short-vined or Semi-bush or Compact | Bush |
|---|---|---|---|
| Butternuts | | | |
| | Waltham | Harris Butternut | Burpee Butterbush |
| | Nicklow's Delight | Early Butternut | |
| | | Butter Boy | |
| Buttercups | | | |
| | Burgess | Autumn Cup | |
| | Sweet Mama | Black Forest | |
| | | Chestnut | |
| Acorns | | | |
| | Tuffy | Autumn Queen | Cream of the Crop |
| | | Mesa Queen | Table Gold |
| | | Table Ace | Table King |
| | | Tay-Belle | |
| Others | | | |
| | Delicata | | |

the rows were sidedressed with calcium nitrate at a rate of 325 lb/A (50 lb/A N). Soil pH was about 6.5 at both sites; lime was not applied.

*Weed control.* Weeds were controlled with an unincorporated post-planting application of Curbit 3EC (ethalfluralin) at a rate of 3.5 pt/A. Occasional tall weeds that arose above the vines late in the growing season did not interfere with vine production or harvest of fruit.

*Insect control.* Squash vine borers and striped cucumber beetles were controlled with three-four applications of Asana XL (esfenvalerate) at a rate of 9.6 oz/A. Applications in July were 7-10 days apart.

*Disease control.* Powdery mildew, black rot, anthracnose, and phytophthora were controlled with alternate biweekly applications of Bayleton 50DF (triadimefon - 4 oz/A) + Bravo 720 (chlorothalonil - 2 pt/A) and Benlate DF (benomyl - 8 oz/A) + Ridomil/Bravo 81W (metalaxyl + chlorothalonil - 3 lb/A) from mid-July through late August. Downey mildew was observed in early September only on the crop at Mt. Carmel, but a late treatment, just before harvest, was deemed unnecessary. As the crop neared maturity in late September 1998, each cultivar of butternut and acorn squash was evaluated for powdery mildew resistance at each site.

*Irrigation.* In 1998, the crops at both sites were irrigated with 0.5-1.0 inches of water in late August. In 1997, irrigation was not applied.

*Harvest of fruit.* Mature fruit were harvested October 1-16. Fruit of each cultivar were counted and weighed individually. The width of the zone in which 90% of the fruit lie (fruiting zone) on either side of the center of the row was measured. This zone excludes outliers of fruit that formed on vines that are longer than normal for the cultivar. Vine length was measured from the root crown to the growing tip of the vine. Where vines branched, the length of the dominant vine was measured. At least five vines along the row were chosen at random for measurement. Vines that did not contain fruit of marketable size were excluded from the sample.

*Rainfall.* Rainfall distribution throughout the growing season (May-October) for 1997-1998 is shown in Table 2. The inches of rainfall in each column represents the departure from the mean monthly rainfall for Hartford (near Windsor) and Mt. Carmel reported by the National Weather Service. Total rainfall during the 1997 and 1998 growing seasons was 19.3 and 29.5 inches at Windsor respectively, and 17.9 and 28.5 inches at Mt. Carmel compared to a 30-year average of 19.2 inches at Windsor and 19.9 inches at Mt. Carmel.

Although total rainfall in the 1997 growing season at Windsor was 0.1 inches above normal, water deficits between 0.6 and 2.4 inches were observed in June, September, and October. At Mt. Carmel, water deficits exceeding 1.5 inches occurred in all months of the growing season except June and August. Heavy rains in August, exceeding 8.1 inches, initially speeded growth of the vines but prolonged soil wetness retarded vine growth and fruit formation in the latter part of the month. Water deficits in September and October also slowed fruit growth as they reached maturity.

Although total rainfall in the 1998 growing season at Windsor was 10.3 inches above normal, water deficits

Table 2. Departure of monthly rainfall (inches) from normal during May-October, 1997-1998.

| | 1997 | | 1998 | |
|---|---|---|---|---|
| | WINDSOR | MT. CARMEL | WINDSOR | MT. CARMEL |
| MAY | 0.16 | -1.49 | 4.06 | 2.32 |
| JUNE | -0.58 | -0.04 | 4.89 | 7.49 |
| JULY | 1.64 | -1.68 | -0.92 | -2.19 |
| AUGUST | 2.55 | 5.23 | -1.92 | 2.04 |
| SEPTEMBER | -2.40 | -2.43 | -1.55 | -1.30 |
| OCTOBER | -1.20 | -1.59 | 2.30 | 0.21 |

between 0.9 and 1.9 inches occurred consecutively in July, August, and September. In May and June, total rainfall reached 15.5 inches. Heavy rains in late May reduced germination of most cultivars, some excessively. Heavy rains in June caused occasional 24-hour ponding and coated the leaves of young seedlings with silt. Although most seedlings survived, their normal growth rate was impeded until new leaves formed at the growing tip.

At Mt. Carmel, total rainfall during the 1998 growing season was 8.6 inches above normal, but deficits of 1.3 and 2.2 inches occurred in July and September, respectively. In May and June, total rainfall reached 16.0 inches. Heavy rains in late May reduced germination of most cultivars. Heavier rains in June caused ponding for 2-3 day intervals and the moderately well drained soil was saturated for most of the month. Growth of seedlings was impaired and early fruit set was delayed.

## YIELD OF FRUIT

### *1997 Crop*

Average yield of six cultivars of butternut squash was 12.5 T/A at Windsor, compared to 14.4 T/A at Mt. Carmel (Table 3). The higher average yield at Mt. Carmel was due to heavier fruit (3.0 lb vs 2.4 lb) because average fruit/acre was slightly greater at Windsor (9,900 vs. 9,750). Yield of long-vined Nicklow's Delight exceeded 21 T/A at both sites. At Windsor, yield of Harris Butternut exceeded 15 T/A, as did Butter Boy and Waltham at Mt. Carmel.

Average yield of five cultivars of buttercup squash was 23.1 T/A at Windsor, compared to 8.3 T/A at Mt. Carmel, an increase of 178%. The greater average yield at Windsor was due to greater fruit/A (13,995 vs. 5,690) and greater average weight/fruit (3.3 lb vs. 2.8 lb). Long-vined Burgess Buttercup had the greatest yield/A at both sites, but its yield at Windsor (30.6 T/A) was over twice its yield at Mt. Carmel (14.4 T/A). At Windsor, yield of Autumn Cup and Sweet Mama exceeded 22 T/A.

Yield of Delicata squash was greater at Windsor (8.4 T/A) than at Mt. Carmel (1.1 T/A). Fruit were more numerous and heavier at Windsor. Very poor germination at Mt. Carmel sharply reduced yield.

### *1998 Crop*

Average yield of five cultivars of butternut squash was 16.3 T/A at Windsor, compared to 9.8 T/A at Mt. Carmel, a 66% difference (Table 4). Greater yield at Windsor was due to greater average fruit/A (12,690 vs. 8,800) and heavier fruit (2.6 lb vs. 2.2 lb). Lower yield at Mt. Carmel was due to stunting of vine growth and aborted flowers by heavy rains in June. At Windsor, yield of long-vined Nicklow's Delight and Waltham exceeded 18 T/A. At Mt. Carmel, yield of Nicklow's Delight, Harris Butternut, and Butter Boy exceeded 10 T/A.

Average yield of eight cultivars of acorn squash was 13.2 T/A at Windsor, compared to 7.4 T/A at Mt. Carmel, a 70% difference. Greater average yield at Windsor was due to greater average total fruit/A (16,825 vs. 11,310) and greater weight of fruit (1.6 lb vs. 1.2 lb). At Windsor, short-vined Tay-Belle, and Mesa Queen had yields exceeding 17 T/A. Mesa Queen's high yield was due to large numbers of fruit (19,600/A) and moderately heavy fruit (1.9 lb). Although Tay-Belle had fewer fruit/A than Mesa Queen, it had the heaviest fruit (2.1 lb) among all acorn cultivars. Table King, a bush cultivar, had the greatest number of fruit/A among all acorn cultivars (21,490), but their average weight was 1.4 lb. Tuffy had the lowest total fruit/A (6,535) among all acorn cultivars and their fruit weighed least (1.2 lb).

At Mt. Carmel, Table Ace and Tay-Belle had yields about 10 T/A. Again, Tay-Belle had the heaviest fruit (1.4 lb), but Table Ace's total fruit/A was among the highest

Table 3. Yield of Butternut and Buttercup Winter Squash at Windsor and Mt. Carmel - 1997.

| | WINDSOR | | | | MT. CARMEL | | | |
|---|---|---|---|---|---|---|---|---|
| CULTIVAR | Avg. Wt./ Fruit lb. | Total Fruit No./A* | Total Yield T/A** | Ctn/A** | Avg. Wt./ Fruit lb. | Total Fruit No/A* | Total Yield T/A** | CtnA** |
| BUTTERNUTS | | | | | | | | |
| Butter Boy | 2.6 | 7,260 | 9.4 | 472 | 2.6 | 12,920 | 16.8 | 840 |
| Burpee Butterbush | 1.7 | 6,245 | 5.3 | 265 | 1.8 | 10,165 | 9.1 | 457 |
| Early Butternut | 2.3 | 6,825 | 7.8 | 392 | 3.0 | 7,695 | 11.5 | 577 |
| Harris Butternut | 2.5 | 13,505 | 16.9 | 844 | 3.1 | 7,695 | 11.9 | 596 |
| Nicklow's Delight | 3.0 | 14,520 | 21.8 | 1,089 | 3.5 | 12,340 | 21.6 | 1,080 |
| Waltham | 2.5 | 11,035 | 13.8 | 690 | 4.0 | 7,695 | 15.4 | 770 |
| BUTTERCUPS | | | | | | | | |
| Autumn Cup | 3.3 | 13,650 | 22.5 | 1,126 | 2.9 | 4,500 | 6.5 | 326 |
| Black Forest | 2.6 | 12,485 | 16.2 | 812 | 2.5 | 1,890 | 2.4 | 118 |
| Burgess | 3.4 | 18,005 | 30.6 | 1,530 | 3.0 | 9,585 | 14.4 | 719 |
| Chestnut | 2.9 | 13,070 | 19.0 | 948 | 2.2 | 4,645 | 5.1 | 255 |
| Sweet Mama | 4.3 | 12,775 | 27.5 | 1,373 | 3.4 | 7,840 | 13.3 | 666 |
| OTHERS | | | | | | | | |
| Delicata | 1.2 | 14,085 | 8.4 | 422 | 1.0 | 2,180 | 1.1 | 54 |

*Based on 7260 linear feet of row/A at 6-foot spacing between rows ÷ 50-foot test row = 145.2 50-foot segments/A x total fruit/50 foot test row segment.

**Based on total fruit/A x avg. weight/fruit ÷ 2000 lbs. or 40 lb/standard carton.

(15,390). Table Gold had the most total fruit/A (15,680), but their weight was lowest (0.9 lb) among all cultivars.

Yield of Delicata was greater at Windsor (7.1 T/A) compared to Mt. Carmel (4.5 T/A). Delicata fruit were more numerous and heavier at Windsor that at Mt. Carmel.

## PLANT CHARACTERISTICS

Plant characteristics can be used to establish planting densities that will maximize yield. Long-vined cultivars of butternut, buttercup, and acorn squash have 10-40 foot vines with fruit forming along most of their length. At a standard planting distance of 6-8 feet (Maynard and Hochmuth 1997), these cultivars form a carpet of leaves as the vines from adjacent rows coalesce and their fruit lie randomly on either side of the row. Development of short-vined cultivars allows closer planting between rows (3-5 feet) and most fruit are set closer to the center of the row. The fruit of bush cultivars, whose plant habit is very compact, lie very close to the center of the row and are treated as most row crops with intertilling. Let us now examine some plant characteristics measured in 1997 and 1998.

### *1997 Crop*

*Germination.* Average germination of six cultivars of butternut squash and five cultivars of butttercup squash was 57% and 59% respectively at Windsor compared to 29% and 32% at Mt. Carmel (Table 5). Lower germination at Mt. Carmel reflected excessive soil moisture at the time of planting. Although most cultivars were treated with a fungicide, poor germination resulted in poor stand density at Mt. Carmel. At Windsor, germination of butternuts Waltham, Harris Butternut, and Early Butternut and buttercups Sweet Mama, Chestnut, and Autumn Cup exceeded 60%. At Mt. Carmel, germination of butternuts Butter Boy and Nicklow's Delight and buttercup Sweet Mama exceeded 40%.

*Average vine length.* Average vine length of six cultivars of butternut squash at Windsor and Mt. Carmel was about 9.0 feet at both sites (Table 5). Average vine length of five

Table 4. Yield of Butternut and Acorn Winter Squash at Windsor and Mt. Carmel - 1998.

| | WINDSOR | | | | MT. CARMEL | | | |
|---|---|---|---|---|---|---|---|---|
| CULTIVAR | Avg. Wt./ Fruit lb. | Total Fruit No/A* | Total Yield T/A** | Ctn/A** | Avg. Wt./ Fruit lb. | Total Fruit No/A* | Total Yield T/A** | Ctn/A** |
| BUTTERNUTS | | | | | | | | |
| Butter Boy | 2.2 | 12,195 | 13.4 | 671 | 2.0 | 10,165 | 10.2 | 508 |
| Early Butternut | 2.9 | 11,470 | 16.6 | 832 | 2.0 | 9,440 | 9.4 | 472 |
| Harris Butternut | 2.5 | 12,050 | 15.1 | 753 | 2.3 | 9,150 | 10.5 | 526 |
| Nicklow's Delight | 2.5 | 14,810 | 18.5 | 926 | 2.6 | 7,985 | 10.4 | 519 |
| Waltham | 2.8 | 12,925 | 18.1 | 905 | 2.3 | 7,260 | 8.3 | 417 |
| ACORNS | | | | | | | | |
| Autumn Queen | 1.5 | 19,020 | 14.2 | 713 | 1.2 | 11,615 | 7.0 | 348 |
| Cream of the Crop | 1.6 | 16,410 | 13.1 | 656 | 1.1 | 12,925 | 7.1 | 356 |
| Mesa Queen | 1.9 | 19,600 | 18.6 | 931 | 1.3 | 11,180 | 7.3 | 363 |
| Table Ace | 1.5 | 17,715 | 13.3 | 664 | 1.3 | 15,390 | 10.0 | 500 |
| Table Gold | 1.2 | 17,280 | 10.4 | 518 | 0.9 | 15,680 | 7.1 | 353 |
| Table King | 1.4 | 21,490 | 15.0 | 752 | 1.0 | 11,325 | 5.7 | 283 |
| Tay-Belle | 2.1 | 16,550 | 17.4 | 869 | 1.4 | 13,795 | 9.7 | 483 |
| Tuffy | 1.2 | 6,535 | 3.9 | 196 | 1.1 | 9,875 | 5.4 | 272 |
| OTHERS | | | | | | | | |
| Delicata | 0.9 | 15,680 | 7.1 | 353 | 0.7 | 12,780 | 4.5 | 224 |

*Based on 7,260 linear feet of row/A at 6-foot spacing between rows ÷ 50-foot test row = 145.2 50-foot segments/A x total fruit/50-foot test row segment.

**Based on total fruit/A x avg. weight/fruit ÷ 2000 lbs. or 40 lb./standard carton.

cultivars of buttercup squash was 22 feet at Windsor compared to 14.9 feet at Mt. Carmel. Although lower populations of buttercup cultivars at Mt. Carmel reduced competition among plants within the row, vine length did not increase as might be expected. Among the long-vined cultivars of butternut squash, Waltham and Nicklow's Delight had the longest vines at both sites. The short-vined butternut cultivars Butter Boy, Early Butternut, and Harris Butternut had 5-10 foot vines at both sites. The bush cultivar Butterbush had 2.5-4.0 foot vines at both sites.

Among the buttercups, average vine length of long-vined cultivar Burgess was 38 feet at Windsor and 24 feet at Windsor. Its vines sprawled across rows planted 18 feet away. The average vine length of long-vined Sweet Mama exceeded 20 feet at Windsor. The vines of short-vined cultivars Autumn Cup, Black Forest, and Chestnut averaged 10-20 feet in length. The vines of these "short-vined" cultivars are as long as long-vined cultivars of butternut and acorn squash, and require above-average spacing between rows.

*Fruiting zone.* Irrespective of vine length, the space occupied by most fruit on either side of the row's center (fruiting zone) is a parameter that will subsequently be used to maximize plant density and yield. The fruiting zone of long-vined butternut Waltham and Nicklow's Delight with their 12-16 foot vines extending on either side of the row's center, had 90% of their fruit occupying a 15-foot wide zone straddling the center line at both sites, i.e. most fruit developed within 7.5 feet from the base of the plant (Table 5). The fruiting zone of the short-vined cultivars Butter Boy, Early Butternut, and Harris Butternut, with their 5-10 foot vines, was 5-8 feet wide at both sites. The fruiting zone of bush cultivar Butterbush was only 2.5-3.0 feet wide at both sites.

Among the buttercup squash, the fruiting zone of long-vined Burgess, with their 24-28 foot vines, was 13-24 feet wide at both sites. This cultivar clearly sets most of its fruit within 7-12 feet from the base of the plant but its unproductive vines extend 17-24 feet beyond. The fruiting zone of short-vined Autumn Cup, Black Forest, and

Table 5. Germination and Plant Characteristics of Butternut and Buttercup Winter Squash at Windsor and Mt. Carmel - 1997.

| | WINDSOR | | | | MT. CARMEL | | | |
|---|---|---|---|---|---|---|---|---|
| CULTIVAR | Germ. % | Avg. Vine Length ft. | Width Fruiting Zone* ft. | Fruit/ Vine No. | Germ. % | Avg. Vine Length ft. | Width Fruiting Zone* ft. | Fruit/ Vine No. |
| BUTTERNUTS | | | | | | | | |
| Butter Boy | 41 | 6.6 | 5.0 | 1.2 | 40 | 5.1 | 5.0 | 2.2 |
| Burpee Butterbush | 57 | 3.9 | 3.0 | 0.8 | 31 | 2.6 | 2.5 | 2.2 |
| Early Butternut | 61 | 9.8 | 6.0 | 0.8 | 20 | 8.1 | 5.0 | 2.6 |
| Harris Butternut | 66 | 8.2 | 8.0 | 1.4 | 22 | 7.2 | 5.0 | 2.4 |
| Nicklow's Delight | 50 | 12.9 | 15.0 | 2.0 | 41 | 16.0 | 15.0 | 2.1 |
| Waltham | 67 | 12.1 | 15.0 | 1.1 | 18 | 15.2 | 11.0 | 2.9 |
| BUTTERCUPS | | | | | | | | |
| Autumn Cup | 62 | 15.8 | 12.0 | 1.5 | 30 | 14.2 | 2.5 | 1.0 |
| Black Forest | 48 | 17.6 | 10.0 | 1.8 | 17 | 9.9 | 4.0 | 0.8 |
| Burgess | 50 | 38.0 | 24.0 | 2.5 | 25 | 24.1 | 13.5 | 2.6 |
| Chestnut | 64 | 17.8 | 10.0 | 1.4 | 34 | 13.2 | 3.0 | 0.9 |
| Sweet Mama | 72 | 21.0 | 11.0 | 1.2 | 55 | 13.0 | 4.0 | 1.0 |
| OTHERS | | | | | | | | |
| Delicata | 41 | 9.0 | 7.5 | 2.4 | 5 | 7.3 | 3.0 | 3.0 |

*Width of zone containing at least 90% of fruit. Excludes outliers which formed on vines of greater length than normal.

Chestnut were 10-12 feet wide at Windsor but only 2.5-4.0 feet at Mt. Carmel. The fruiting zone of Sweet Mama was almost three times wider at Windsor (11.0 feet) than at Mt. Carmel (4.0 feet).

*Fruit per vine.* The number of marketable fruit/vine is a measure of the productivity of each cultivar. The average number of marketable fruit/vine of all butternut cultivars was 1.2 fruit at Windsor compared to 2.4 fruit at Mt. Carmel, a two-fold increase (Table 5). The fact that the average germination at Windsor (57%) was twice that of Mt. Carmel (29%) suggests that reduced competition among plants within the row increases marketable fruit/vine.

Among the buttercup cultivars, the average marketable fruit/vine was 1.7 at Windsor compared to 1.3 at Mt. Carmel. It is apparent that less competition among fewer buttercup plants at Mt. Carmel did not produce more fruit/plant as it had done for butternuts. Apparently the buttercup cultivars were more sensitive to excessive rainfall than butternut cultivars in August (8 inches) as vines were actively setting fruit. The heaviest fruit set at both sites occurred on Burgess, a long-vined cultivar.

Germination of Delicata squash was poor at Windsor (41%) to very poor at Mt. Carmel (5%). Its moderately long vines (7-9 feet) produced 2.4-3.0 fruit/vine at both sites.

### *1998 Crop*

*Germination.* Average germination of five cultivars of butternut squash was 44% at Windsor compared to 48% at Mt. Carmel (Table 6). Compared to 1997 (Table 5), average germination at Windsor was 13% less but 19% more at Mt. Carmel. At Windsor, Waltham had the greatest germination (50%) and Early Butternut the least (37%). At Mt. Carmel, germination of Butter Boy, Early Butternut, and Harris Butternut exceeded 50%.

The average germination of eight cultivars of acorn squash was 54% at Windsor compared to 66% at Mt. Carmel. Germination rates of acorn cultivars were greater than those of butternut cultivars. At both sites, Cream of the Crop (66%) and Tay-Belle (68%) had greater germination rates than all other acorns.

*Vine length.* The average vine length of five butternut cultivars was 8.2 feet at both sites (Table 6). The average vine length of Waltham, a long-vined cultivar, was greatest

Table 6. Germination and Plant Characteristics of Butternut and Acorn Winter Squash at Windsor and Mt. Carmel - 1998.

| | WINDSOR | | | | MT. CARMEL | | | |
|---|---|---|---|---|---|---|---|---|
| CULTIVAR | Germ. % | Avg. Vine Length ft. | Width Fruiting Zone* ft. | Fruit/ Vine No. | Germ. % | Avg. Vine Length ft. | Width Fruiting Zone* ft. | Fruit/ Vine No. |
| BUTTERNUTS | | | | | | | | |
| Butter Boy | 48 | 5.7 | 5.0 | 1.8 | 57 | 6.2 | 5.7 | 1.2 |
| Early Butternut | 37 | 7.5 | 6.7 | 2.1 | 54 | 9.4 | 9.0 | 1.2 |
| Harris Butternut | 45 | 6.0 | 5.3 | 1.8 | 55 | 6.5 | 3.9 | 1.1 |
| Nicklow's Delight | 41 | 10.5 | 9.9 | 2.5 | 33 | 8.6 | 9.9 | 1.7 |
| Waltham | 50 | 11.2 | 11.5 | 1.8 | 40 | 10.5 | 9.8 | 1.2 |
| ACORNS | | | | | | | | |
| Autumn Queen | 60 | 6.8 | 3.5 | 2.2 | 52 | 4.4 | 4.3 | 1.5 |
| Cream of the Crop | 66 | 2.7 | 3.3 | 1.7 | 80 | 1.9 | 2.5 | 1.1 |
| Mesa Queen | 54 | 6.2 | 7.0 | 2.5 | 68 | 4.2 | 4.0 | 1.1 |
| Table Ace | 58 | 5.0 | 3.0 | 2.1 | 70 | 6.8 | 5.2 | 1.5 |
| Table Gold | 46 | 1.5 | 2.5 | 2.6 | 63 | 3.4 | 3.0 | 1.7 |
| Table King | 64 | 1.5 | 1.8 | 2.3 | 67 | 1.7 | 1.8 | 1.2 |
| Tay-Belle | 68 | 6.6 | 5.2 | 1.7 | 76 | 4.3 | 4.1 | 1.2 |
| Tuffy | 17 | 9.4 | 8.5 | 2.6 | 56 | 7.6 | 6.0 | 1.2 |
| OTHERS | | | | | | | | |
| Delicata | 51 | 5.6 | 4.3 | 2.1 | 50 | 5.0 | 4.2 | 1.8 |

*Width of zone containing at least 90% of fruit. Excludes outliers which formed on vines of greater length than normal.

at both sites (10-11 feet). Average vine length of Butter Boy was least among all butternut cultivars (6 feet).

The average vine length of eight cultivars of acorn squash was 5.0 feet at Windsor and 4.3 feet at Mt. Carmel. Tuffy, a long-vined cultivar, had the greatest average vine length (8-9 feet) at both sites. The average vine length of bush types, Cream of the Crop, Table Gold, and Table King varied between 1.5 and 3.3 feet at both sites.

*Fruiting zone.* The average in five butternut cultivars was 7.7 feet at both sites (Table 6). Waltham and Nicklow's Delight had the widest fruiting zone (10-12 feet); Butter Boy and Harris Butternut had the narrowest zone (4-6 feet).

The average width of fruiting zone of eight cultivars of acorn squash was greater at Windsor (4.4 feet) compared to Mt. Carmel (3.9 feet). Long-vined Tuffy had the widest fruiting zone at both sites (6.5-8.0 feet). The bush cultivars, Cream of the Crop, Table Gold, and Table King had the narrowest fruiting zones at both sites (1.8-3.3 feet).

*Fruit per vine.* The average fruit/vine in five cultivars of butternut squash was 2.0 at Windsor compared to 1.3 at Mt. Carmel (Table 6). Compared to 1997, average fruit/vine increased at Windsor and decreased at Mt. Carmel. Reduction in average fruit/vine at Mt. Carmel was due to excessive rain in June 1998 which reduced fruit set and stunted many plants to the extent that their fruit never reached marketable weight (12 ounces).

The average fruit/vine of eight cultivars of acorn squash was 2.2 at Windsor compared to 1.3 at Mt. Carmel. Again, heavy rains in June reduced fruit set, and stunted many plants. At Windsor, Cream of the Crop and Tay-Belle had the least fruit/vine. Since both of these cultivars also had the greatest germination rate, it appears that competition between plants reduced the number of marketable fruit. At Windsor, a detailed inventory of the fruiting habit of individual plants in the population of Cream of the Crop at Windsor was informative. Twenty percent of the population were stunted and had no marketable fruit; 30% produced one fruit/vine; 21% produced two fruit/vine, 23% produced three fruit/vine, 4% produced four fruit/vine, and 2% produced six fruit/vine.

## MANAGEMENT

### *Selection of cultivars*

Selection of suitable cultivars for commercial production is usually based on yield and uniformity of fruit. For the

home garden, space requirements are more relevant. From these trials it is clear that, with uniform plant spacing, long-vined cultivars generally produce greater yields than short-vined or bush cultivars. Although yields were lower, short-vined and bush cultivars produce ample fruit for winter storage. Let us now look at several cultivars each of butternut, buttercup, and acorn squash that had high yields and appealing quality for the commercial grower and home gardener.

*Butternuts.* Nicklow's Delight, a long-vined cultivar, had greater yields in three of four plantings compared to all other butternut cultivars. Its high yield was related to the great number of fruit/A and often the high weight of fruit. The fruit are mostly thick-necked, have a relatively small seed cavity, and are borne on vines that are 10-15 feet long. For home gardens, the long vines may be burdensome.

Waltham, another long-vined cultivar, had satisfactory yields in both years. Compared to Nicklow's Delight, more of Waltham's fruit were in the 3-5 lb range, but a greater number of fruit were elongated, and seed cavities were larger.

Harris Butternut had the greatest yields among the short-vined cultivars in two of four plantings. Although yields were smaller than long-vined cultivars, their 5-9 foot vines produced up to 2.4 fruit/vine. Fully 66% of fruit were in the 2-4 lb range. This cultivar may be suited for commercial production and home gardens.

Butterbush, the only bush cultivar tested, had low yields, but its 2-4 foot vines produced 1.7 fruit/vine and were confined to a narrow 3-foot wide fruiting zone. Thirty percent of its fruit exceeded 2 lb. This cultivar is well suited to home gardens but has commercial applications if planted at a narrower row spacing to increase yield.

*Buttercups.* Burgess, a long-vined cultivar, had the greatest yield among all buttercups. Its 24-38 foot vines produced 2.5 fruit/vine, weighing 3.0-3.5 lb and spread over a 13-24 foot fruit zone. High productivity, however, comes at a price of high space requirements. The fruit of Burgess contain a large blossom scar 3-4 inches in diameter. It is more suited for commercial production than home gardens.

Sweet Mama, another long-vined cultivar, had shorter vines than Burgess (13-21 feet) and a narrower fruiting zone (4-11 feet). Although total fruit/A was slightly less than Burgess, its fruit were heaviest (4.3 lb) among all buttercups. Fully 66% of its fruit weighed 3-5 lb compared to 51% of Burgess's fruit; 25% weighed over 5 lb. The fruit of Sweet Mama also contains a conspicuous blossom scar. This cultivar is suited for commercial production.

Autumn Cup, a short-vined cultivar, yielded over 25 T/A at Windsor. Its 15-foot vines produced 1.5 fruit/vine in a 12-foot fruiting zone. Although the average fruit weighed slightly less than Burgess or Sweet Mama (3.0 lb), its appeal lies in the inconspicuous scar at the blossom end of the fruit (less than 1 inch diameter). Buttonless fruit are easier to peel than fruit with large buttons. This cultivar would appeal to both commercial production and home gardens although its space requirements are greater than short-vined cultivars of butternut and acorn squash.

*Acorns.* Mesa Queen, a short-vined cultivar, had the greatest yield among all acorn cultivars at Windsor (18.6 T/A). Its 4-6 foot vines produced 2.5 fruit/vine in a fruiting zone 7 feet wide. The fruit weighed an average of 1.9 lb with 71% in the 1-2 lb range. This cultivar is well suited for both commercial production and home gardens.

Tay-Belle, another short-vined cultivar, had the second greatest yields at both sites. Although the total fruit/A was not greatest at both sites, the weight/fruit was greatest at Windsor (2.1 lb) and Mt. Carmel (1.4 lb). At Windsor, 57% of Tay-Belle's fruit ranged between 2-3 lbs, and 5% exceeded 3 lbs. This cultivar is well suited for commercial production and home gardens.

Table King had the greatest yield among all bush cultivars at Windsor. Among all acorn cultivars, it produced the greatest number of fruit/A (21,490). The greenish black fruit were borne on 1.5-foot vines and its fruiting zone was 1.8 feet wide. The average weight/fruit was about 1.5 lb with 72% falling within the 1-2 foot range. This cultivar is well suited for home gardens and if planted at a closer row spacing, yield would improve for commercial production.

Cream of the Crop, a bush cultivar producing cream colored fruit, had a high yield at Windsor (13.1 T/A). Its vines were 2.0-2.5 feet long and its fruiting zone was 2.5-3.3 feet wide. At both sites, the average weight/fruit was 1.1-1.6 lb and 64% was in the 1-2 lb range; 25% exceeded 2 lb, the greatest among bush cultivars. This cultivar is well suited to home gardens. Although the color of its rind is unique, its taste and quality were excellent.

*Planting density.* Variable planting density can be used to maximize yield. Studies of pumpkin yields by Reiners and Riggs (1997) showed that numbers of marketable fruit increased as spacing within rows decreased from 1.2 to 0.3 meters (4-1 feet). Average fruit size, however, decreased at the closer spacing except on irrigated fields where moisture was maintained at optimum levels. Edelstein et al. (1989) found similar results with vined and bush cultivars of spaghetti squash.

According to traditional plant and row spacing for winter squash (Maynard and Hochmuth 1997), distance between plants within rows range between 3-8 feet for vining cultivars and 2-4 feet for bush cultivars. The distance between rows ranges from 6-8 feet for vining cultivars and 3-5 feet for bush cultivars. At these spacings between plants and rows, the density/A ranges between 680-2420 plants for vining cultivars and 2178-7620 plants for bush types.

Spacings for these trials were uniform irrespective of the vining habit of the cultivars tested. Seeds were sown at 6-inch intervals within each row with the intention of thinning to a 1-foot spacing. Germination, however, at 40-

60% in most cultivars, provided a natural thinning. Since the cultivars tested were long-vined, short-vined, and bush intermixed, I chose an intermediate spacing of 6 feet between rows. The following suggested spacings between rows are based on observations of vining and fruiting habits of the cultivars.

| | | |
|---|---|---|
| Butternuts and acorns | long-vined | 6 feet |
| | short-vined | 5 feet |
| | bush | 3 feet |
| Buttercup | long-vined | 8 feet |
| | short-vined | 6 feet |

At these spacings, competition between plants in adjacent rows is minimal. For long-vined and short-vined cultivars, vines from adjacent rows will intermingle, forming a vegetative carpet. This carpet will discourage late weed growth. Narrower 3-foot-spacings between rows for bush cultivars could increase yield/A, perhaps as much as two-fold compared to a 6-foot spacing. A 5-foot spacing between rows of short-vined cultivars could increase yield/A as much as 17% compared to a 6-foot spacing.

*Disease control.* Powdery mildew and downy mildew control usually prevents late-season defoliation of squash leaves that support growing fruit. Without adequate control, the only fruit that reach marketable size are those first formed along the vine. Growth of late-forming fruit farther along the vine is usually curtailed and these fail to reach marketable size. In 1998, despite alternate applications of Bayleton 50WP and Ridomil/Bravo 81W from mid-July through late August, wet, cold weather in the last week of August and the first week of September caused defoliation of leaves as powdery mildew rapidly developed at Windsor and downy mildew developed at Mt. Carmel. The cultivars of butternut and acorn squash were evaluated at both sites to determine their tolerance to defoliation (Ferrandino, et al. 1999). Statistical analysis showed that the acorn cultivars Tuffy and Table Gold were significantly more tolerant to defoliation compared to all others. All butternut cultivars were moderately susceptible to defoliation. Amber Cup, a kabocha type squash used as guard rows, was highly resistant to defoliation. Delicata squash, on the other hand was highly susceptible at both sites.

*Site selection.* In 1997 and 1998, average yield of all cultivars of winter squash at Windsor was 5.7 and 6.1 T/A greater, respectively, than the average yield of all cultivars at Mt. Carmel. Although the sandy soil at Windsor holds less water for crop utilization, this soil drains well following excessive rainfall. This soil is less compact and responds more rapidly to supplementary nitrogen fertilization. The loamy soil at Mt. Carmel is moderately well drained. In times of excessive rainfall (August 1997 and May-June 1998), ponding occurred and slow drainage hindered plant growth and development of fruit.

In short, moderately well drained soils are poorer sites for squash production than well drained sites. In times of drought, sandy soils may require supplementary irrigation for optimum production.

*Post harvest storage.* Winter squash, free from injury or decay, can be stored at optimum temperatures of 50-55F and relative humidity of 50-70% (Maynard and Hochmuth 1997). Under optimum conditions, butternut squash may be kept 6 months or more, buttercup squash 2-3 months, and acorn squash 1-2 months (Ferro, et al. 1998). To allow movement of air, fruit should not be piled.

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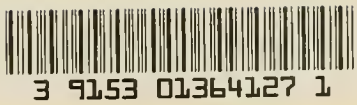

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